Deep Generative Models in Engineering Design: A Review

Year: 2021 | Citations: 242 | Authors: Lyle Regenwetter, A. Nobari, Faez Ahmed

---

Abstract

Automated design synthesis has the potential to revolutionize the modern engineering design process and improve access to highly optimized and customized products across countless industries. Successfully adapting generative Machine Learning to design engineering may enable such automated design synthesis and is a research subject of great importance. We present a review and analysis of Deep Generative Learning models in engineering design. Deep Generative Models (DGMs) typically leverage deep networks to learn from an input dataset and synthesize new designs. Recently, DGMs such as Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), feedforward Neural Networks (NNs) and certain Deep Reinforcement Learning (DRL) frameworks have shown promising results in design applications like structural optimization, materials design, and shape synthesis. The prevalence of DGMs in Engineering Design has skyrocketed since 2016. Anticipating continued growth, we conduct a review of recent advances with the hope of benefitting researchers interested in DGMs for design. We structure our review as an exposition of the algorithms, datasets, representation methods, and applications commonly used in the current literature. In particular, we discuss key works that have introduced new techniques and methods in DGMs, successfully applied DGMs to a design-related domain, or directly supported development of DGMs through datasets or auxiliary methods. We further identify key challenges and limitations currently seen in DGMs across design fields, such as design creativity, handling constraints and objectives, and modeling both form and functional performance simultaneously. In our discussion we identify possible solution pathways as key areas on which to target future work.